A Critical Study of the Biceps Cruris Muscle as it Relates to Disease in and Around the Knee-Joint.

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A CRITICAL STUDY OF THE BICEPS CRURIS MUSCLE AS IT RELATES TO DISEASE IN AND AROUND THE KNEE-JOINT.[1]

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DISEASES in and around the knee-joint are of such common occurrence, and are so serious in their results, that facts throwing light upon their etiology and the conditions which produce them are of interest, not only to the surgeon, but to the medical practitioner, under whose care many of them first come.

The object of this paper is to present the results of an original investigation of the anatomical relations of the *biceps muscle*, and the role it plays in the production and continuance of diseases in and around the knee-joint.

In order to present the subject clearly it will be necessary to review briefly the anatomical relations of the muscles which act with the biceps as flexors and rotators of the leg, also, some of the tissues which enter into the structure of the knee-joint. The flexors of the leg, exclusive of the biceps, are seven in number, viz.: the semitendinosus; semimembranosus, sartorius, gracilis, popliteus, gastrocnemius and plantaris.

The first four may be termed the analogues of the biceps. They take origin at the pelvis and from the aponeuroses of adjacent muscles become tendinous at some point above the internal condyle of the femur and are inserted into the tibia below the line of attachment of the capsular ligament. Of these four muscles the semimembranosus alone is closely connected with the joint. Its tendon spreads out into a broad fasciculus, which is applied to its posterior ligament forming a strong and even support to it; from thence it passes to its in-

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sertion upon the inner and anterior surface of the tibia. Owing to this low attachment and to the laxness of the posterior ligament during flexion the semimembranosus does not make strong traction upon joint tissue even in forcible flexion of the extremity.

The three remaining flexors take origin from the posterior surface of the lower extremity of the femur and are attached to the tibia. Of these, only the popliteus is in close relation to the joint. It arises from the posterior ligament as well as from the external condyle of the femur. Its tendon passes through an opening in the capsule and coronary ligament behind the external inter-articular cartilage. As it passes through the joint it is invested by synovial membrane; yet, notwithstanding this intimate relation, it does not pull upon tissue inside the joint even in extreme flexion of the leg.

In addition to their office as flexors the semimembranosus and popliteus rotate the leg inward, the sartorius and gracilis act as abductors of it.

The capsular or anterior ligament of the knee-joint is a thin but strong fibrous structure which bridges the space between tibia, femur and patella. It extends laterally as far as the external and internal condyles of the femur, where it becomes continuous with the posterior or ligament of Winslow. It is supported and strengthened by overlying ligaments and aponeuroses, by which also (through their muscular connections) it is retracted from between the joint surfaces during movement of the leg. It is everywhere lined by synovial membrane, and is inseparably connected with all the tissues within the joint.

The inter-articular fibro-cartilages differ materially in form and mobility.

The inner takes the shape of a slender crescent. Its extremities are firmly attached to the articular surface of the tibia at its anterior and posterior border, and its convex margin to the inner surface of the capsular ligament by means of a narrow band called the coronary ligament. At its widest part it measures one and one-half cm. The range of movement of this cartilage is comparatively limited, being held in place by its close attachment (through the capsule) to the broad, in-

ternal lateral ligament, and to the aponeurosis of the internal vastus muscle. Owing to this attachment it is more easily ruptured than displaced.

The form of the external articular cartilage is that of a circle not quite complete; its extremities are fastened in front of and behind the spine upon the articular surface of the tibia; this places them at the very center of the knee-joint in close relation with the crucial ligaments, to the posterior of which the cartilage is also attached. At its widest part it measures one centimeter. Like its fellow it is united to the capsule by means of the coronary ligament, which also attaches it posteriorly to the ligament of Winslow. Its entire circumference is traversed by this ligamentous band, with the exception of a section one centimeter in extent at its outer part, where a button-hole-like opening exists for the passage of the tendon of the popliteus muscle. (I have not found the cartilage grooved at this point for the passage of this tendon as is stated by some authors). To the posterior angle of this slit fascilulus from the biceps (to be described later) is attached. Owing to its extensive capsular attachment, its own pliability and especially to the shape and movement of the articular surfaces to which it is applied, the range of movement of the external cartilage is extensive. The amount of surface covered by synovial membrane also is large, as compared with that of its fellow upon the inner side.

The synovial membrane which lines every portion of the joint is especially subject to friction in three regions, viz.:

1. On the line of attachment of the capsular ligament to the tibia, anteriorly (owing to traction of the coronary ligaments in sudden and forced flexion of the leg, and to blows from without).

2. At the point of insertion of the crucial ligaments and cornua of the external articular cartilage.

3. Behind the long external lateral ligament near the head of the fibula.

Inflammation of the synovial membrane is most persistent in these regions, owing, doubtless, to the fact that the greatest amount of friction during movement occurs here.

Up to this point I have been unable to find any muscle which by virtue of its anatomical relation makes special traction upon the capsular ligament, inter-articular cartilage or synovial membrane of the knee-joint.

In beginning a critical study of the biceps we are at once confronted by the fact that this one muscle on the outer side of the thigh performs alone the work shared by several muscles on the inner side, which indicates a complex arrangement of muscular fibre, and a functional activity in excess of its fellows. It takes origin at the pelvis in close connection with the semi-tendinosus; its fibres pass downward and outward. Some of them become tendinous in the upper third of the thigh, forming the beginning of the ribbon-like fibrous band which traverses the remainder of the muscle, becoming below its tendon of attachment to the fibula. All of the pelvic fibres join this tendon at some point above the outer condyle of the femur. The name "long head" is commonly applied to this upper portion of the muscle.

The short or femoral head arises from the linea aspera, external supra-condyloid ridge and external inter-muscular septum. Its line of origin extends from the middle of the femur (sometimes higher) to a point four or five centimeters above the outer condyle. The fibres which take origin from the linea aspera pass downward and outward and *end* in the aponeurotic band described in connection with the "long head." They increase the leverage power of the muscle materially. The fibres from the supra-condyloid ridge and inter-muscular septum pass in the same direction but do not *end* in the aponeurotic band; they join it, pass down along its anterior border and spread out on its femoral surface. Three or four centimeters above the head of the fibula a group of them separate, become fibrous and are applied to the capsular ligament at its junction with the ligament of Winslow. These act the part of a tractor of the capsule and inter-articular cartilage. The remaining fibres from the supra-condyloid ridge become tendinous opposite the head of the fibula, divide in two slips, a superficial and deep, between which the long external lateral ligament passes to its insertion into the head of the fibula. The superficial slip is closely connected with

the fibular tendon of the biceps, it crosses the tibia to a small, but strong insertion near the outer border of the ligamentum patellæ.

FIG. I.—BICEPS CRURIS MUSCLE WITH ITS ATTACHMENTS.

1. Long head.
2. Portion of "short head" from linea aspira.
3. Fibular tendon.
4. Portion of short head from supra-condyloid ridge and intermuscular septum.
5. Tractor of capsule and articular cartilage.
6. Tibial tendon of biceps.
7. Capsular ligament.
8. Long external lateral ligament.

The deep portion of the tibial tendon, much larger than the superficial, crosses the tibia beneath the lateral ligament. In passing to its insertion, it not only plays over the surface of the capsule above the head of the fibula, but blends with it along its line of attachment to the tibia, and some fibres pass upward upon it as far as the insertion of the coronary ligament. (Fig. II). This intimate relation between the biceps muscle, the capsular

ligament and through it with the interarticular cartilage and synovial membrane has not, so far as I know, been heretofore described.

FIG. II.—TIBIAL TENDON OF BICEPS, SHOWING ITS RELATION TO THE CAPSULAR LIGAMENT AND EXTERNAL ARTICULAR CARTILAGE.

1. Fibula disarticulated and drawn backward.
2. Tibia.
3. Articular surface for fibula.
4. Portion of intra-capsular surface of tibia over which the tibial tendon plays.
5. External condyle of femur.
6. Tibial tendon of biceps.
7. External inter-articular fibro-cartilage.
8. Long external lateral ligament.
9. Cut edge of capsular ligament.

To recapitulate, we have in the biceps cruris a muscle which crosses three joints. It arises by two heads and has three tendons of insertion. The fibres comprising the long head, and those of the short head which arise from the linea aspera, make up a muscle, the tendon of which is inserted into the head of the fibula. The remaining fibres of the short head are inserted into the capsule behind the tendon of the popliteus, and into the tibia anteriorly, blending with the capsular ligament, more or less, by the way.

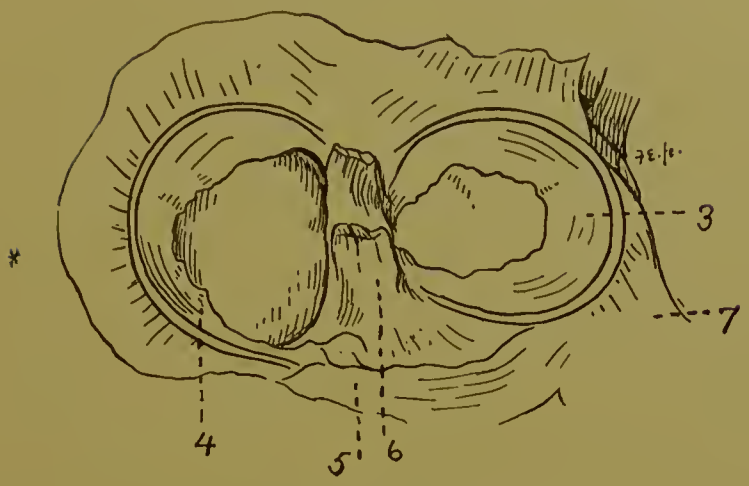

FIG. III.—INTERIOR OF KNEE-JOINT.
Quadriceps extensor and patella reflected.
Inter-articular fibro-cartilages in position of extension of leg.

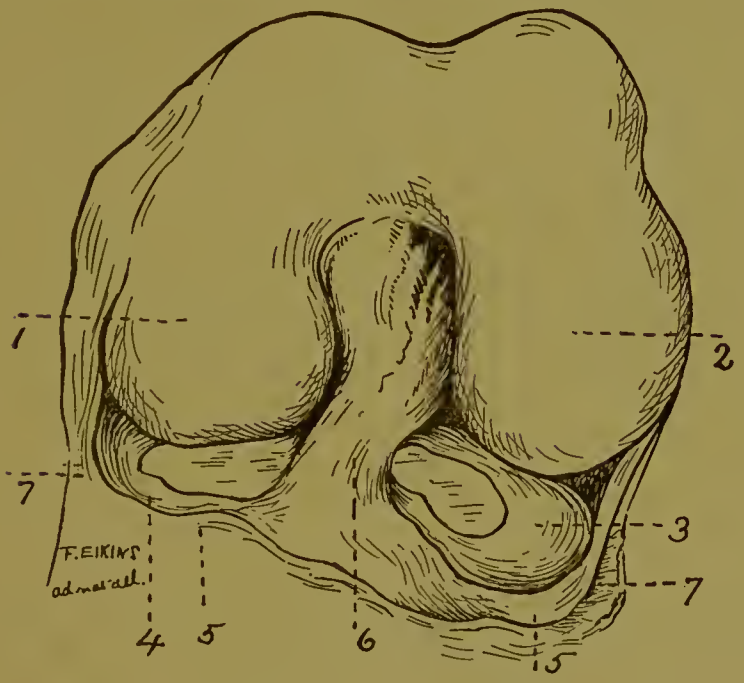

FIG. IV.—INTERIOR OF KNEE-JOINT.
Inter-articular fibro cartilages in position of flexion of leg.
1. Internal condyle of femur.
2. External condyle of femur.
3. External inter-articular cartilage retracted as in ordinary flexion of the leg.
4. Internal inter-articular cartilage in flexion of leg.
5. Coronary ligaments.
6. Crucial ligaments.
7. Capsular ligamet.

In the accompanying figures (Figs. III, IV and V) are shown the effects of traction upon this capsular slip of the fibres of insertion of this muscle. In Fig. III, the nearly circular form of the external fibro-cartilage and its narrow insertion are shown, and it is easy to understand the greater degree of mobility enjoyed by it in consequence of this anatomical relation. Fig. IV shows the relation of the fibro-cartilage in ordinary flexion of the knee; in Fig. V is seen the change in the position of the external fibro-cartilage, where in addition to flexion a sharp pull at the biceps muscle has been made.

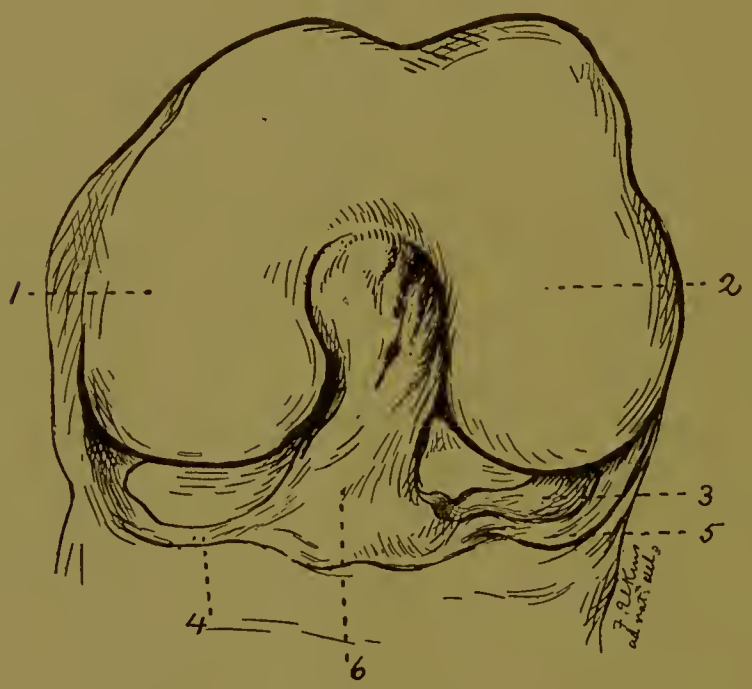

FIG. V.—INTERIOR OF KNEE-JOINT.

External inter-articular cartilage drawn backward and outward by forcible traction of tractor tendon of biceps muscle during flexion of leg.

1. Internal condyle of femur.
2. External condyle of femur.
3. External articular cartilage displaced by action of biceps.
4. Internal articular cartilage.
5. External coronary ligament.
6. Crucial ligaments.

The biceps muscle acts as a flexor of the leg, an external rotator and a retractor of the capsular ligament and interartic-

ular cartilage. With such a leverage upon the tissues in and around the knee-joint, it is not difficult to believe that sudden and forced action of the biceps muscle as in a stumble up stairs, over the curb stones or downward, might produce serious injury within the joint, to the capsular ligament or to the periosteum at its own point of attachment to the tibia.

Disease of the joint or periosteum once established, how can it be otherwise than that the action of the biceps should tend to perpetuate it?

The nutrition of the knee becomes impaired by disease more promptly perhaps than that of any other joint, and when impaired is regained more slowly.

All who are familiar with knee joint affections know that long continued disease means long delayed recovery. Any measure, therefore, which makes it possible to exercise the joint, either actively or passively, without injury, means a shortening of the time during which its unfortunate possessor must remain physically inactive.

In view of the fact that serious injuries to the knee occur most often during the movement of flexion of the leg, also that the internal flexor muscles, by virtue of their low insertion, etc., make no special traction on the joint, it is reasonable to conclude that the action of the biceps-cruris is, in *some* cases, the exciting cause of inflammation in and around the knee, and in a large number of joint diseases its movement is a grave source of irritation.

The practical question now arises, can a tenotomy or myotomy be performed to relieve this tension, without disturbing the integrity of the joint?

Section of the outer ham string would of course accomplish the desired result, so far as lessening tension is concerned; but the possibility of producing continued lameness by such an operation would deter the surgeon from making it, except in very grave cases. A tenotomy of the superficial and deep slips of the tibial tendon, in front of the external lateral ligament, is a more simple operation, and was effective in the case which will be reported in connection with this paper.

But an incision down to the bone so near the border of attachment of the capsular ligament, and the tibio fibular articulation, is not entirely free from danger, especially as there is in this region, in some knees, a passage of communication between the two joints.

In my study of the biceps, I discovered that the muscular fibers taking origin from the external supra condyloid ridge of the femur and the intermuscular septum are the only ones which make traction upon the capsular ligament. These fibers accompany the fibular tendon as far as its insertion, becoming tendinous at this point. To exsect them in some part of their course would seem to be a comparatively simple procedure, and one which would not be likely to involve injury to contiguous tissue. I would, therefore, suggest the following operation, hoping it may prove so safe that it can be resorted to, not only in long-continued and serious cases of knee joint diseases, but in the early stage of cases which, if allowed to go on, may become chronic.

Make an incision, beginning four centimeters above the upper part of the head of the fibula, extend it upward between the biceps and ilio-tibial band of the fascia lata. Dissect down to the biceps, isolate it and remove *all* the muscular fibers found in connection with it at this point. (It should be remembered that these fibers line its femoral surface, as well as run along its anterior margin.)

Remove also a small V-shaped piece from the anterior border of the tendon; close the wound with ordinary antiseptic precaution.

Begin movement of the leg as soon as possible after healing is accomplished.

By this proceedure the friction produced upon tissues in and around the joint, by traction of the biceps, will be removed; possibly, also, the cutting off of so large a section of the muscle will diminish rotary movement within the articulation, and thus, in some degree, give additional rest to inflamed tissues.

Illustrative Case.—Miss A. B., æt. 44. Physical history good;

has led a very active life until eleven years ago, when she took a position which necessitated a sedentary one.

In January, 1882, she sat in a public meeting where the seats had been closely crowded together. Owing to their construction no change of posture could be made to relieve the strain produced by extreme flexion of the lower extremities. Two hours and a half in this cramped position produced discomfort almost amounting to pain. She passed a restless night afterward, and the next day both knees were so stiff and lame that walking was difficult. The second day she took a journey on the cars, and visited a large institution, climbing many flights of stairs, etc. During the return journey she first noticed twinges of pain in the left knee, which were somewhat relieved by extension of the leg. On the third day the pain became more constant, and slight swelling was observed below the patella. She walked little during the next few days, and tincture of iodine was applied. The pain continued and a deep soreness was complained of. At the end of a week movement became so difficult that she gave up the effort to walk, and did not again bear her weight upon the limb for nearly a year.

Hot fomentations, blisters, both superficial and deep, the actual cautery, electricity, all were used, at one time or another, with no apparent good results. At the end of six weeks a plaster splint was applied from hip to toes, which greatly relieved the pain. A couple of months in bed resulted in improvement, and in the summer she was taken to the seashore.

Ten months after the onset of the disease she began to walk without the splint, with cane and crutch.

She was now unwisely permitted to resume the duties of her position, and soon over-exerted both herself and the knee which produced a return of the trouble.

The surgeons who had seen the case up to this time had pronounced it a mild case of synovitis, although it lacked many of the distinguishing features of synovial inflammation. There had never been any indication of fluid in the joint, and a direct blow on the sole of the foot caused no pain in the knee. On the other hand, flexion of the leg always produced pain, and movement was followed by an increase of soreness, which the patient located upon the front of the head of the tibia.

There was at no time demonstrable increase in size, except along the line of the tibial attachment of the capsular ligament, in which region there was some swelling from the beginning, increasing the size about an inch. There was, however, a marked lack of symmetry over the entire knee.

The patient was seen at this time by one of the most eminent surgeons in this country, who, after careful examination, said that there was no synovitis, but a general inflammation of fibrous tissue on the front of the knee, involving especially the patellar ligament. As he enjoined absolute and long-continued rest in bed, she was removed to a private room in a large hospital. Here she came under the care of another surgeon of wide experience, who pronounced the condition a bursitis, affecting especially the bursa beneath the ligamentum patellæ.

Poultices, compression and deep blistering were tried in succession. No improvement being manifest, he advised extirpation of the subpatellar bursa, saying "without the operation the knee would never get well." The patient objected, and aspiration was made to confirm the diagnosis. No fluid was withdrawn.

The next surgeon under whose care she came believed the affection to be a sub-acute periostitis. He put the extremity in an excision splint, to give it complete rest, and had an ice bag applied across the front of the joint continuously for several weeks. Under this treatment a decided gain was perceptible, and for the time being pain was entirely subdued.

Three months from the time she entered the hospital a long silicate of potash splint was applied, and, with a high soled boot on the other foot, she was permitted to move around on crutches, and shortly to leave the hospital

The splint was kept on six months, at the end of which time the circulation in the leg had become greatly impaired; venous congestion was intense when in the upright position

Having changed her residence she now consulted a noted professor of surgery, who pronounced the condition a synovitis, involving especially the fibrous tissue outside the joint. He advised her to remove the splint and to slowly bring the extremity into use. After faithful effort on her part and many discouraging set-backs, the patient, at the end of eight months more, was able to walk two or three blocks unaided. Movement, however, was always followed by aching in the knee, and sudden flexion of the leg, with the superimposed weight of the body upon it, was almost certain to produce a return of pain and soreness, which only continued rest would relieve.

At this stage began a chapter of accidents which continued during the next five years. A mis-step on the stairs, a trip of the foot upon a rug, a kick of the toe against an obstruction, rendered the limb useless from six weeks to six months, repeatedly, so that at the end of

seven years from the time of the accident, a year and a half was the longest she had been off crutches at once. She had not been able to use the limb to step up and down stairs in the ordinary way, the attempt to do so always producing such soreness as threatened to lay her aside.

The knee reached its best condition in the summer of 1887, when a fall down stairs was followed by a new attack of inflammation.

Dr. J. D. Rushmore, of Brooklyn, now saw the case in consultation. He believed the condition to be a periostitis, located upon the anterior surface of the tibia, and perpetuated by traction of tissue in movement of the extremity. He considered the possibility of relieving this tension by an incision, but decided that this was not feasible. He recommended rest in the recumbent posture for a few weeks, after which a Judson brace was applied, and movement on crutches allowed. At the end of nine months (five of which were passed in the South under good hygienic conditions), the patient regained use of the extremity, but the knee was weak, and movement fatigued it greatly.

After six months of limited activity another accident occurred which necessitated a return to crutches.

About this time I made a somewhat careful dissection of a knee, with special reference to the symptoms presented in this case, and discovered a fact which, up to this time, had been overlooked, viz., that the surface where tenderness to pressure had all the time been most marked corresponded to that *covered by the attachment of the tibial tendon of the biceps muscle.* A further study of the relation of this tendon to the periosteum and capsular ligament led me to conclude that the action of the biceps muscle was not only the source of irritation, which had perpetuated the disease, but the original cause of trouble.

Long-continued forced flexion of the leg was the first fact recorded in the history of the case. Repeated injuries due to sudden flexion followed. Inability to recover the use of the extremity in stepping up and down stairs—these and many minor facts led to this conclusion. Dr. Rushmore thought this might be a solution of the problem which had puzzled so many wise heads, and recommended division of the tibial tendon of the muscle.

Several other surgeons saw the case at this time, and all concurred in the opinion that such an operation would do no harm, if it were not productive of good.

The statement was made by two that the knee would probably never be of much use, unless relieved by surgical interference. Accordingly,

on December 22, 1888, Dr. Rushmore performed the operation, Prof. C. L. Ford, Prof. Jarvis Wight and others being present.

An incision was made, beginning in front of the fibular attachment of the external lateral ligament, extending obliquely downward and forward six cm. The tissues were carefully separated down to the tibial tendon of the biceps, which was then incised as far behind its point of insertion as possible. The wound was closed without special antiseptic precautions. It healed within ten days, and the patient resumed the use of crutches. The only change observed subjectively was a sense of freedom in movement of the leg not felt before. From this time the deep soreness, so long complained of, began to abate, and motion was not always followed by pain. She was able to discard crutches in a few weeks, and the knee went on to recovery without a set-back. The usual number of mis-steps, etc., have since been made, and on several occasions she has fallen headlong over obstructions. These accidents were followed by stiffness and more or less pain, which, however, passed over in a few days. At no time has she been obliged to discontinue the use of the extremity. At the present time, two and one-half years after the operation, she leads a very active life, she does not limp, is able to walk half a mile without discomfort, can step up and down stairs, and stand an hour or more without over fatigue to the knee.

The muscles above the knee have all regained their normal size, *except the lower half of the short head of the biceds*, which has undergone marked atrophy, a distinct depression outlining its location. External rotation is slightly impaired, and the external ham string tendon is a little less tense than the internal in flexion of the leg. Up to the present time this is the only case recorded in which section of the tibial tendon of the biceps has been performed. In this case if the operation had been done within the first year the patient would, doubtless, have been spared years of suffering.